UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2011/2012

Januari 2012

EBB 427/3 – Technology & Application of Engineering Polymer
[Teknologi & Penggunaan Polimer Kejuruteraan]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains THIRTEEN printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA BELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of TWO questions from PART A and FIVE questions from PART B.
[Kertas soalan ini mengandungi DUA soalan dari BAHAGIAN A dan LIMA soalan dari BAHAGIAN B.]

Instruction: Answer **ALL** questions from PART A and **THREE** questions from PART B. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **SEMUA** soalan dari BAHAGIAN A dan **TIGA** soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

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PART A:

***BAHAGIAN A*:**

1. [a] Briefly explain the definition of hydrocarbon polymers, heterochain polymers and carbon-chain polymers.

Terangkan secara ringkas definasi polimer hidrokarbon, polimer rantaian hetero dan polimer rantaian karbon.

(15 marks/*markah*)

[b] By using a suitable example, discuss how structures within the molecules and structures between the molecules influence the polymer properties.

Dengan menggunakan contoh yang sesuai, bincangkan bagaimana struktur di dalam molekul dan struktur antara molekul mempengaruhi sifat sesuatu polimer.

(40 marks/*markah*)

[c] Select TWO applications of the polymer listed in (i-iv), propose a suitable engineering polymer for each of the application by considering polymer structure-property interrelationship:

(i) Reinforcement for hoses, belt and tires.
(ii) Electrical switches and connectors.
(iii) Chemical storage container.
(iv) Windshield for planes and helicopters.

Pilih DUA aplikasi polimer yang disenaraikan dalam (i-iv), cadangkan polimer kejuruteraan yang sesuai bagi setiap aplikasi yang dipilih dengan mengambilkira perkaitan di antara struktur-sifat polimer:

(i) Tetulang bagi salur, tali dan tayar.
(ii) Suis elektrik dan penyambung.
(iii) Bekas penyimpan bahan kimia.
(iv) Penghadang angin bagi kapal terbang dan helikopter.

(45 marks/*markah*)

2. [a] Based on information provided in Table 1, comment on how the ratio of epichlorhydrin to bisphenol A affect the properties of epoxy resin.

Berdasarkan maklumat yang disenaraikan di dalam Jadual 1, komen bagaimana nisbah epiklorhidrin kepada bispenol A mempengaruhi sifat-sifat resin epoksi.

Table 1: Effect of molar ratio

Jadual 1: Kesan nisbah molar

Molar ratio epichlorhydrin:bisphenol A / *Nisbah molar epiklorohidrin: bispenol A*	Molecular weight / *Berat molekul (g/mol)*	Softening temperature / *Suhu pelembutan (°C)*
10.00 : 1	370	9
2.00 : 1	451	43
1.40 : 1	791	84
1.33 : 1	802	90
1.25 : 1	1133	100
1.20 : 1	1420	112

(30 marks/*markah*)

[b] From Table 2, it is clear that aromatic amines provide better mechanical properties as compared to aliphatic amines curing system for bisphenol A epoxy resin. Discuss and outline reasons why these differences exist.

Merujuk kepada Jadual 2, aromatik amina menghasilkan epoksi resin yang mempunyai sifat-sifat mekanikal yang tinggi berbanding sistem-sistem aliphatik pematangan. Bincang dan berikan alasan-alasan kenapa ianya berlaku.

Table 2: Typical values for various properties of unfilled castings prepared from liquid bisphenol A-based epoxy.

Jadual 2: Nilai-nilai tipikal sifat-sifat resin cecair epoksi berasaskan bisphenol A yang tidak terisi

Properties / *Sifat*	Curing agent / *Agen pematangan*	
	Aliphatic amines / *Alifatik amina(a)*	Aromatic amines / *Aromatik amina (b)*
Tensile strength / *Kekuatan regangan* (MPa)	48-69	69-90
Compressive strength *Kekuatan mampatan* (MPa)	83-100	120-130
Flexural strength *Kekuatan lenturan* (MPa)	83-100	120
Impact strength, Izod *Kekuatan hentaman, Izod* (J/m)	21-27	27-32
Heat deflection temperature *Suhu haba lenturan* (°C)	70-110	145-150

(30 marks/*markah*)

[c] In aqueous solution, formaldehyde exists in equilibrium with methylene glycol as shown in Figure 1. Depending on the pH of the catalyst, these monomers react to form one of two general resin types: Novolac resin and Resol resin. Based on Scheme 1, describe the resin that will be resulted from the chemical reaction and explain how phenolic to aldehyde monomer ratio, pH, catalyst type, reaction temperature, reaction time, and amount of distillation will produce a resin with wide range of properties.

Di dalam larutan cecair, formaldehid berada pada tahap equilibrium bersama metilena glikol seperti Rajah 1. Bergantung kepada nilai pH katalis, monomer-monomer ini boleh bertindakbalas membentuk dua jenis resin utama iaitu resin Novolak dan resin Resol. Berdasarkan Skema 1, bincangkan jenis resin yang bakal terbentuk daripada tindakbalas kimia tersebut dan terangkan bagaimana ratio phenol kepada formaldehi, pH, jenis katalis, suhu tindakbalas, jangkamasa tindakbalas dan jumlah destilasi mempengaruhi sifat-sifat resin yang dihasilkan.

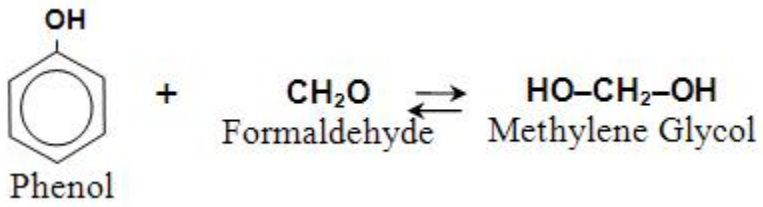
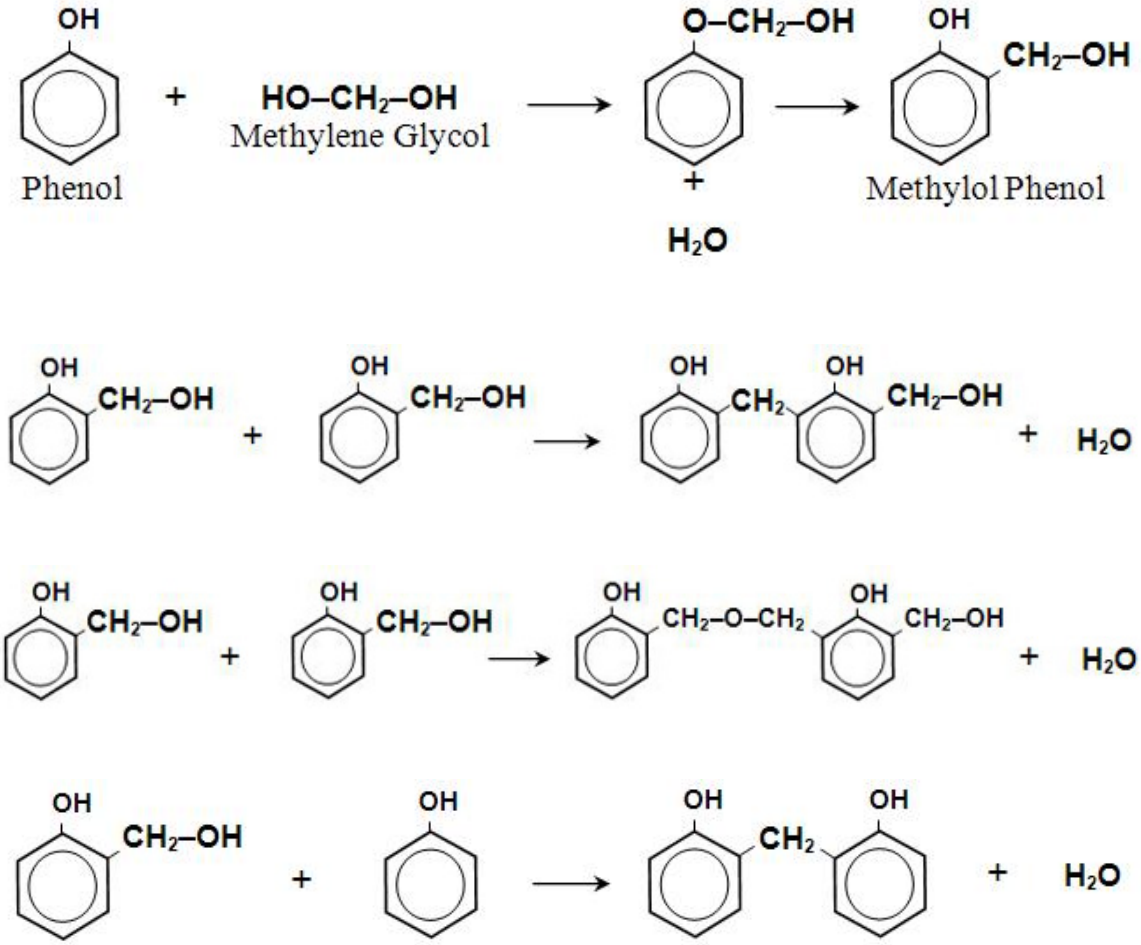


Figure 1: Formaldehyde and Methylene glykol in aqueous solution

Rajah 1: Formaldehida dan Metilena glikol di dalam larutan cecair

SCHEME 1 / SKEMA 1:



(40 marks/*markah*)

PART B:

***BAHAGIAN B*:**

3. [a] Discuss briefly the relationship between the melt temperature and the location of the frost line in blown film manufacturing.

Bincangkan dengan ringkas hubungan di antara suhu lebur dan lokasi garis beku dalam penghasilan filem tiup.

(20 marks/*markah*)

[b] Sketch the designs of an extruder screw for nylon and polyethylene. Discuss the shape of a temperature profile used for nylon and polyethylene when using a general-purpose screw.

Lakarkan perbezaan dalam rekabentuk skru penyemperitan bagi nilon dan polietilena. Bincangkan bentuk profil suhu yang biasa digunakan untuk nilon dan polietilena sekiranya menggunakan skru tujuan-umum.

(40 marks/*markah*)

[c] A deep component (20 cm depth x 10 cm diameter) is to be formed. By using schematic diagrams, compare blow molding and injection molding as processes for making the part. What technical and economic considerations should be considered in determining which method is the best?

Satu komponen yang berlekuk (20 sm dalam x 10 sm diameter) akan dihasilkan. Bandingkan kaedah pengacuanan tiupan dan suntikan acuan dalam penghasilan komponen ini. Pilih kaedah terbaik dengan mengambilkira perbincangan dari segi ekonomi dan teknikal.

(40 marks/*markah*)

4. [a] Some surveys of public perceptions regarding plastics and their impact on the environment have indicated that the public believes that plastics are more detrimental to the environment perhaps any other type of material. These perceptions are based largely on the reports that the amount of discarded plastics is growing and is therefore an ever-increasing component of municipal solid waste. These perceptions have some basis in truth, but are not entirely correct. Give your comment. Answer can be supported by proposing methods to dispose or recycle the plastic waste.

Kajian terhadap tanggapan masyarakat berkaitan dengan plastik dan kesan terhadap alam sekitar mendapati bahawa mereka mempercayai bahawa plastik membawa kesan buruk terhadap alam sekitar berbanding dengan bahan lain. Tanggapan ini adalah berdasarkan laporan mengenai sisa plastik yang semakin meningkat dan seterusnya meningkatkan komponen sisa pepejal perbandaran. Persepsi ini ada kalanya benar, tetapi tidak semestinya betul. Berikan komen anda. Jawapan anda boleh dibantu dengan mencadangkan kaedah pelupusan dan pengitaran sisa buangan plastik.

(50 marks/*markah*)

[b] Discuss several steps involve in reprocessing and refabrication of postconsumer recycle (PCR) materials.

Bincangkan beberapa langkah yang terlibat dalam pemprosesan semula dan penghasilan semula bahan kitar semula lepas guna (PCR).

(30 marks/*markah*)

[c] Suggest TWO alternative ways to reduce the accumulation of waste tyre in Malaysia.

Cadangkan DUA kaedah alternatif untuk mengurangkan timbunan tayar terbuang di Malaysia.

(20 markah/*markah*)

5. [a] Discuss how vinyl liquid monomer could affect the processing and curing characteristics of unsaturated polyester resin.

Bincangkan bagaimana kesan cecair monomer vinil terhadap sifat-sifat pemprosesan dan pematangan poliseter tak tepu.

(25 marks/*markah*)

[b] You are given two types of epoxy resins namely A and B. Determine the pot life for each resin by plotting a suitable graph. You are also required to clearly state the time and viscosity of the resin at the maximum pot life time.

Anda diberi dua jenis resin epoksi A dan B. Dapatkan "pot life" untuk setiap resin dengan lakaran graf yang sesuai.. Anda juga perlu tandakan dengan jelas nilai masa dan kelikatan pada "pot life' maksima.

Time (hours) / *Masa (Jam)*	Change in viscosity (%) / *Perubahan kelikatan (%)*	
	Resin A	Resin B
0	0	0
0.5	15	30
1.0	30	55
1.5	50	80
2.0	65	105
2.5	80	130
3.0	105	160
3.5	120	200
4.0	150	250

(50 marks/*markah*)

[c] Propose a typical formulation for general purpose unsaturated polyester resin and justify your selection.

Cadangkan formulasi tipikal resin poliester pelbagai guna dan berikan justifikasi pemilihan anda.

(25 marks/*markah*)

6. [a] Define the terms “shelf life” and “pot life” with respect to the processing of thermosetting resins.

Terangkan maksud “shelf life” dan “pot life” berdasarkan pemprosesan resin termoset.

(15 marks/*markah*)

[b] Describe the following types of epoxy resins based on their properties and applications:

Terangkan jenis-jenis epoksi berikut berdasarkan sifat-sifat dan kegunaannya.

(i) Diglycidyl ether of bisphenol A (DGEBA) epoxy
Epoksi Diglisidil eter bisfenol A
(ii) Novolac epoxy / *Epoksi Novolak*
(iii) Polyglycol epoxy / *Epoksi Poliglikol*
(iv) Cyclic aliphatic epoxy / *Epoksi alifatik siklik*
(v) Acyclic aliphatic epoxy / *Epoksi alifatik asislik*
(vi) Glycidyl amine epoxy / *Epoksi amina glisidil*

(60 marks/*markah*)

[c] There are several factors that influence the selection of thermosetting adhesive. List and describe each factor that influences your selection in choosing the effective thermosetting adhesive.

Terdapat beberapa faktor yang mempengaruhi pemilihan perekat termoset. Senarai dan terangkan setiap faktor yang mempengaruhi pemilihan perekat yang efektif.

(25 marks/*markah*)

7. [a] Prepregs are commonly used in fabrication of advanced composites based on thermosetting resin system due to cost, performance and ease of processing issues. Explain how the use of prepregs could address the above issues.

Prapreg digunakan dengan meluas di dalam fabrikasi komposit maju berasaskan resin termoset kerana faktor harga, prestasi dan kesediaan pemprosesan. Terangkan bagaimana penggunaan prapreg dapat menangani isu tersebut.

(30 marks/*markah*)

[b] Properties of phenolic resin can be improved by adding severals fillers such as wood flour, cellulose (cotton flock), minerals fillers (mica, clay), silica (SiO_2), graphite fibre and glass fibre. Based on each of the fillers stated above, describe the expected enhancement in properties by adding each of them in phenolic resin.

Sifat-sifat resin fenolik boleh ditingkatkan dengan penambahan beberapa pengisi antaranya seperti serbuk kayu, selulos (cotton flock), pengisi mineral (mica, clay), silika (SiO_2), gentian grafit dan gentian kaca. Berdasarkan kepada penambahan setiap pengisi di atas, terangkan peningkatan-peningkatan sifat yang dijangkakan terhadap resin fenolik.

(30 marks/*markah*)

[c] Table 1 shows comparative mechanical properties of DETA and TETA cured epoxy castings at 25 °C. Comments on the differences between the properties listed in Table 3 by emphasizing on the difference between DETA and TETA properties.

Jadual 1 menunjukkan perbandingan sifat-sifat mekanikal bagi epoksi yang dimatangkan menggunakan DETA dan TETA pada suhu 25°C. Komen mengenai perbezaan-perbezaan sifat mekanikal yang diperolehi berdasarkan sifat-sifat semulajadi DETA dan TETA.

Table 1: Comparative mechanical properties of DETA and TETA cure epoxy castings at 25 °C

Jadual 1: Perbandingan sifat-sifat mekanikal bagi epoksi yang dimatangkan menggunakan DETA dan TETA pada suhu 25°C

Properties / *Sifat*	DETA (10-11 phr)	TETA (13-14 phr)
Heat deflection temperature / *Suhu haba pelenturan,* °C	95 - 124	98 - 124
Flexural strength / *Kekuatan lenturan,* psi	14,500 - 17,000	13,900 - 17,700
Compressive strength / *Kekuatan mampatan,* psi	16,500	16,300
Tensile strength / *Kekuatan regangan,* psi	11,400	11,400
Ultimate elongation / *Pemanjangan ultimat,* %	5.5	4.4

(40 marks/*markah*)

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